# MACLURE SKETCHING AND DRAWING

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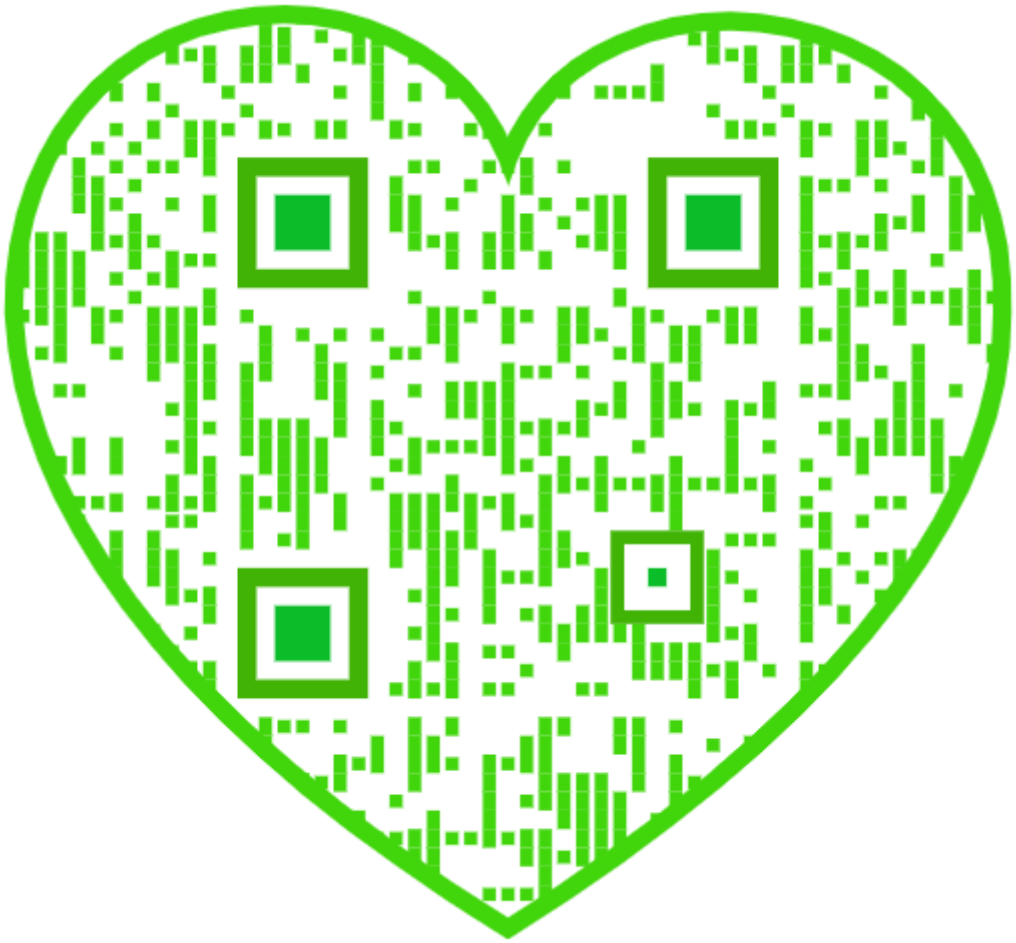

# AN INTRODUCTION

TO

# MACHINE SKETCHING AND DRAWING

FOR

# Industrial and Technical Schools

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## PREFACE

This book is designed primarily for use in classes for machinists in the night industrial schools of the Province of Ontario.

The exercises, when accompanied by the necessary instruction in practical geometry, projection, related mathematics, and simple machine design, will be found suitable for use as the basis of instruction in the junior classes of day industrial and technical schools and in classes for apprentices.

In the preparation of the book, valuable criticisms and suggestions have been received from engineers, draughtsmen, and machine shop foremen, most of whom have had experience in night school teaching, and also from teachers of draughting and machine shop practice in technical schools. Special acknowledgment is made to Mr. H. G. Bertram, John Bertram & Sons, Dundas; Mr. R. Stewart, teacher of machine design, Toronto Technical School; Mr. A. McCall, draughtsman, and Mr. W. J. Henry, machine shop foreman, Collingwood Shipbuilding Company, Collingwood; and Mr. F. E. Braucht, teacher of machine shop practice, Hamilton Technical School.

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## TO THE TEACHER

The object of a short night school course in machine drawing is to give the students the ability (1) to read blue prints and (2) to make simple working sketches and drawings.

The aim in preparing this little book is to put into the hands of the teachers and students a graded series of easy exercises that will assist them in attaining this object.

No exercises in practical geometry or in development of surfaces are given, as they are not needed in an elementary night school course, in which only the objects defined above are sought. Easy working drawings are used from the beginning. The students will, accordingly, at once see the practical bearing of the exercises and their interest, it is believed, will be maintained.

Instructions for the students with reference to new points accompany each exercise. These will enable students to make progress with each drawing without the aid of the instructor. In a large class where individual instruction is used, this should be of considerable assistance to the busy teacher.

The students should use:

(1) Drawing paper of fair quality;
(2) A 4H and a 2H drawing pencil and a soft rubber;
(3) Draughting board, T-square, and set-squares (transparent);
(4) A set of instruments of fairly good quality; and
(5) A scale or fine ruler divided into thirty-seconds of an inch.

## MACHINE SKETCHING AND DRAWING

*The object of mechanical drawing* is to represent a mechanical object in such a way that a skilled workman may make it, with only the drawing as a guide, exactly as the draughtsman intended it to be made. It is necessary, therefore, that a mechanical drawing should show *accurately* the forms, dimensions, and relative positions of all parts of the object represented.

From the beginning the student should strive for *neatness* and *accuracy* in his sketches and drawings. Practice with these ends always in mind will in time give skill.

In order to benefit by this course the following are essential:

(1) Neatness,
(2) Accurate measurement, and
(3) Conformity with standard practice and careful observance of conventional forms.

In a mechanical, or working, drawing, each face of the object is drawn separately and exactly as it appears when looked at from squarely in front of it.

On page 11 is a picture of a small block with three sheets of glass placed parallel to its front, end, and top faces respectively. When the front face is looked at squarely, an outline of that face can easily be drawn on the glass through which the face is viewed. In a similar way the end and the top can be drawn on the other two sheets of glass (see figures 1 and 2). By turning the end and top sheets of glass into the positions shown in figure 3, a mechanical, or working, drawing of the block is obtained.

The drawing of the top is called the "plan"; those of the front and end are called "elevations".

Figure 4 shows how a working drawing of such a block would ordinarily be made. The front elevation is drawn first. The height of the end elevation is obtained by drawing light horizontal lines as shown; the length of the plan, by drawing light vertical lines. These light lines are called projection lines. They are never left on the drawing. This means of obtaining dimensions of one view from another is called "*simple projection*".

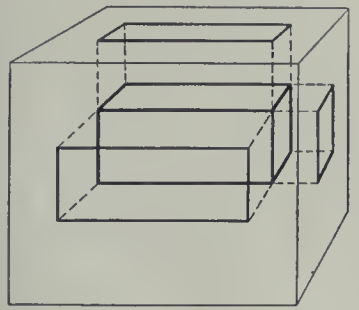


Fig 1.

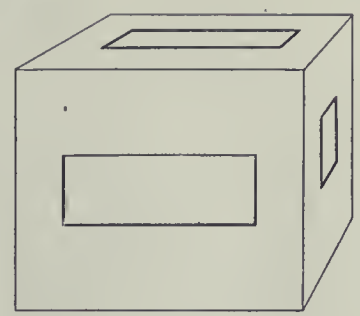


Fig 2.

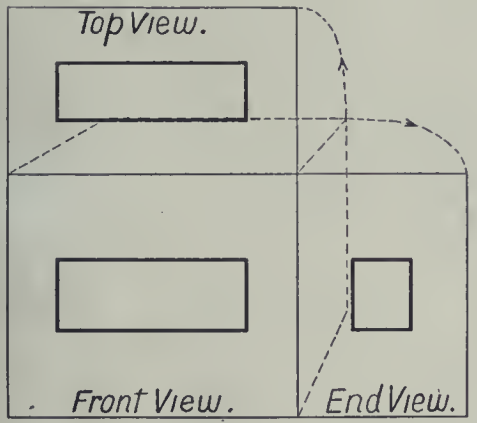



Fig 3.

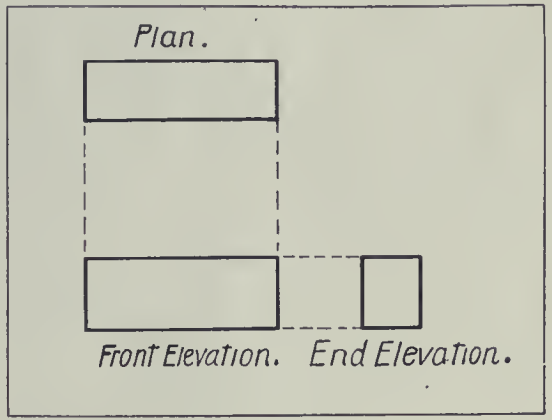



Fig 4.

The picture of the parting tool on page 13 shows (in a similar way to that on page 11) how in mechanical drawing an object is represented by a separate drawing of each face *exactly as it appears* when looked at *from squarely in front of it.*

It is seen from these two pictures (pages 11 and 13) how the plan and elevations are usually arranged—the plan above the front elevation, and the end elevation at whichever side it logically belongs.

Only the *least number of faces* required to give a true representation of the object is drawn. Sometimes two are sufficient and seldom more than three are required.

---

*The teacher* should provide himself with a block, a parting tool, and three panes of glass. With these he should explain to his students this principle upon which the whole course depends. He should not proceed till each student understands it thoroughly.

With each succeeding exercise, he should endeavour to get the students into the habit of viewing an object from squarely in front of the side that is to be drawn—looking down upon it for the plan, etc. In a short time the students should be able to visualize an object that is not placed before them. *The teacher should keep this end in view at the beginning and throughout the course.*

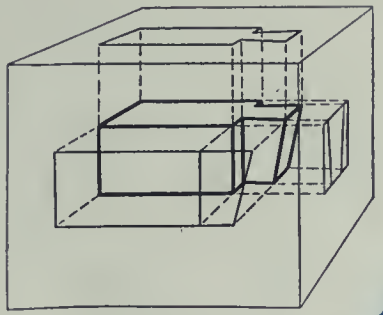


Fig 1.

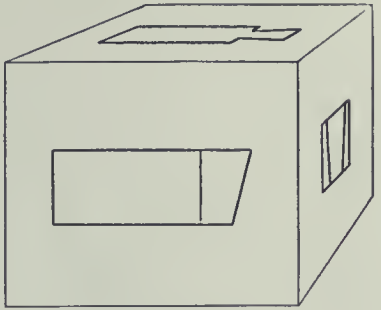


Fig 2.

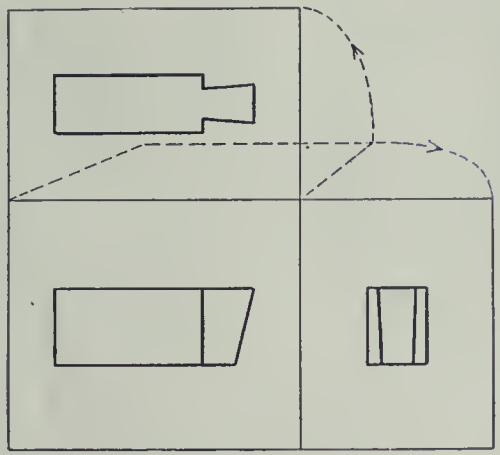


Fig 3.

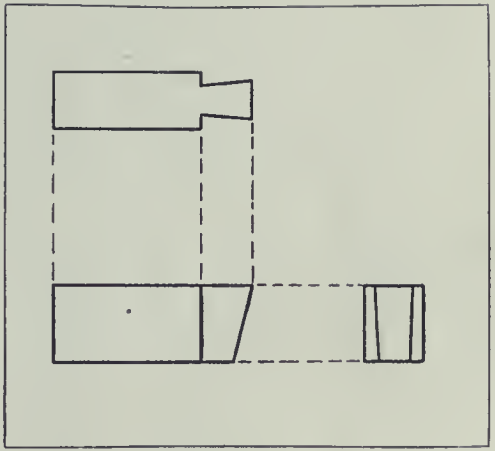


Fig 4.

## The Layout of a Drawing Sheet

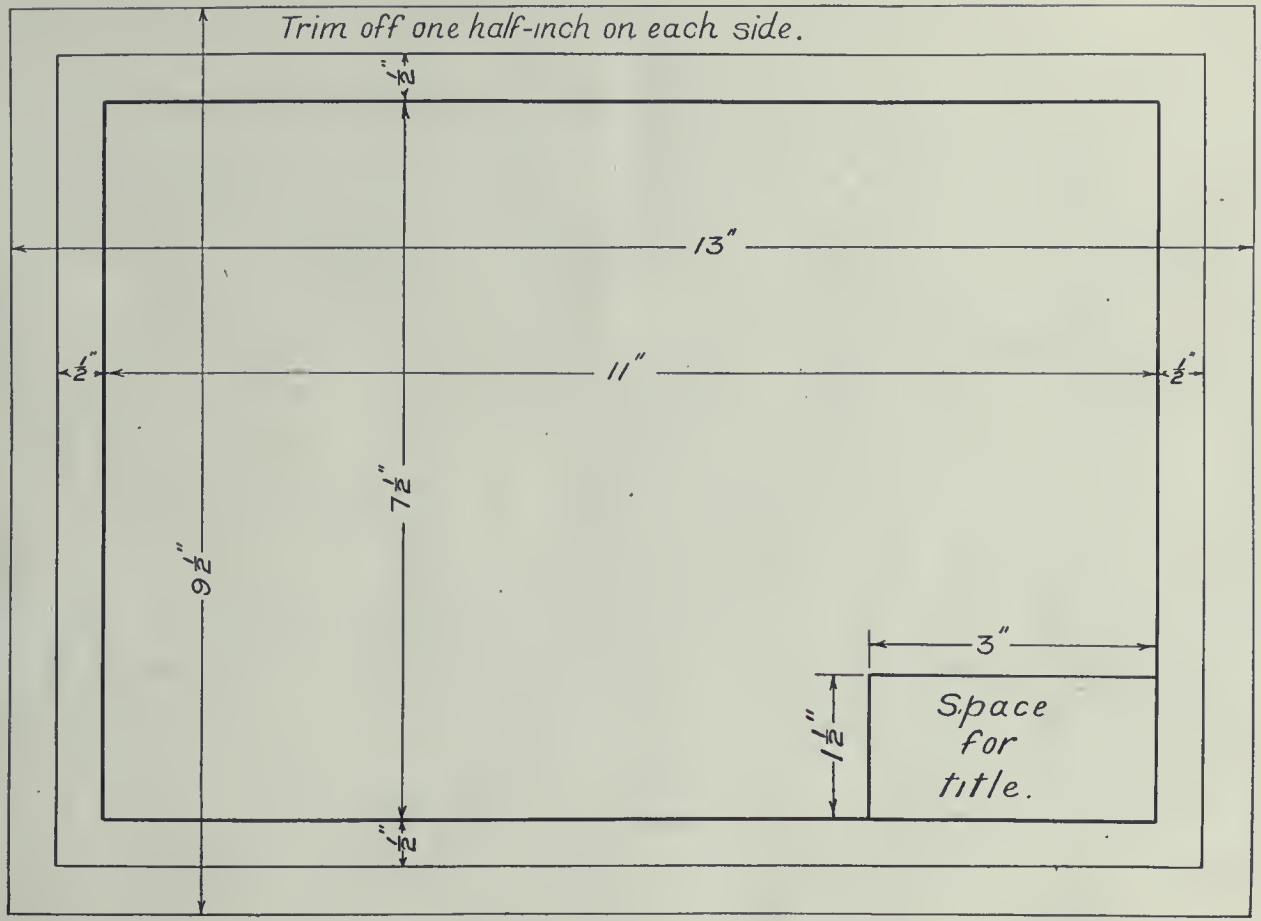
The size of the plates suitable for all the exercises in this book except the last five or six depends on the size of the standard sheets that can be conveniently obtained. These may be 22 in. x 30 in., 26 in. x 38 in., etc., and should be cut to a size that will give a working space of at least 7 in. x 10½ in. A somewhat larger working space will be better if the paper can be cut economically to suit it.

For the last few exercises in the book, the plates must be much larger.

A space 1½ in. x 3 in., ruled off in the lower right-hand corner, is a suitable size for the title, etc.

The layout of a plate that will cut from a 26 in. x 38 in. sheet and will be found suitable is shown on the opposite page.

Note - For reference only. Not to be drawn.



## Lettering

The letters, figures, etc., on page 17 are intended *for reference only,* and the sheet is not to be copied as an exercise.

Lettering is very important in mechanical drawing; poor lettering will spoil the appearance of the best drawing. For night school students, however, it is considered that sufficient practice in lettering will be obtained in connection with the making of the given plates.

All lettering, title included, must be done *freehand.*

All letters and figures in the plates should be made with the greatest care, and the students would do well to practise freehand lettering at spare moments.

Attention to the following points will help the beginner:

1. Do not make the letters too large.
2. Do not make them narrow and high.
3. Space them close.
4. Have the slant of all letters the same.
5. Have the height even.
6. Avoid fancy twists.

The student should always rule three parallel lines to aid him in having the height of his capitals and small letters even.

Two types of letters are shown on page 17. The student should choose the type that suits his hand and use it only.

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

1234567890

## Conventional Lines

Visible Line.

Invisible Line. $\frac{1}{8}$" dashes - $\frac{1}{16}$" spaces.

Section Line.

Centre Line. $\frac{3}{4}$" and $\frac{1}{16}$" dashes - $\frac{1}{16}$" spaces.

Dimension Line $\frac{3}{4}$"

Arrow Heads

RIGHT WRONG

*The title for the given size of drawing should be 3"x1½" and should show:-*

*i Name of piece* *ii Scale of drawing.*

*iii Date finished* *iv Student's signature.*

*Example:- The title for exercise given on page 48 will be:-*

WINCH DRUM.
Scale:- 1½" = 1 Foot.
Nov. 16th 1917. J. Smith.

Note.—(1) *The drawings in this book are purposely not made to scale.*
(2) Read carefully the text opposite each plate before commencing to draw.
(3) The small pictures in the upper corners of pages 19, 23, 25, 27, and 33 are not to be drawn.

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Block.—Draw to scale full size.

On page 19 are a picture and a working drawing of a block of steel.

This is to be drawn *"to scale full size"*; that is, the dimensions of each view in the working drawing are to be exactly the same as those of the face of the block the view represents.

In the working drawing the top is shown in the plan, A; the side in the front elevation, B; and the end in the end elevation, C.

As the bottom of the block is exactly like the top, the back like the front, and the two ends alike, only three views are required to show the workman how the block is to be made.

In making the drawing, the front elevation should be drawn first and the position and one dimension of each of the other views obtained from it by *simple projection.*

*First draught.*—In all sketching and drawing make the first draught *very light,* so that any lines that must be erased will leave no mark on the paper. When the drawing *is complete* go over all the lines again and make them a *good distinct weight.*

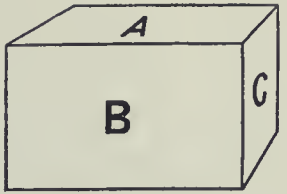
*Dimensioning.*—Read carefully the information and instructions in regard to dimensioning on page 20. These instructions should be closely followed throughout the course.

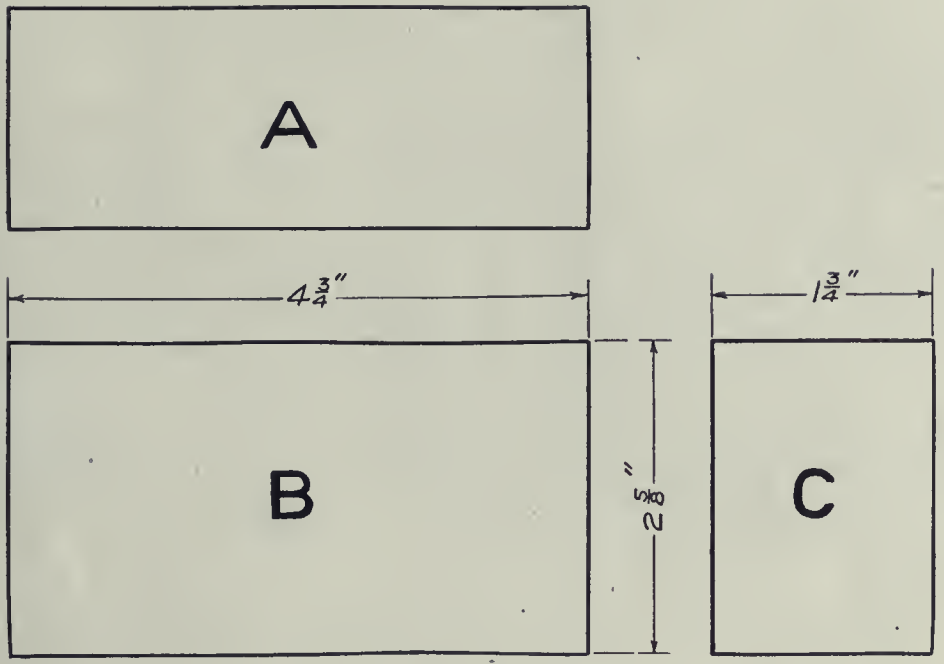
*Title.*—For the position of the title and what it should show, see pages 15 and 17.

---

*The teacher* should provide himself with at least one of each of the first four objects to be drawn by the students—the block, the parting tool, the cast iron valve weight, and the tool slide. They should be used by teacher and students in making the drawings.

If the objects themselves cannot be secured, wooden models of them, made carefully to the dimensions in the sketches, should be used.


A
B
C


A
4 3/4"
1 3/4"
B
2 5/8"
C

## Dimensioning

For the guidance of the mechanic making the object, a working drawing is always dimensioned. A mechanic should always be guided by the given dimensions and should never have to do any measuring on the drawing. Every dimension necessary should be shown but no unnecessary ones. No dimension should be repeated.

*Dimension lines, etc.*

(1) Light continuous lines (see page 17).

(2) Break in middle for figures.

(3) Make arrow-heads as shown on page 21.

(4) Dimension lines on the different sides of a view should be at equal distances from it, and parallel dimension lines should be at equal distances apart. They do not look well too close to the view or too near together; in drawings of ordinary size ¼ inch is common spacing.

(5) Over-all dimension lines should be outside the others. (Examples— 8 5/8″ and 1 1/8″ on page 16)

(6) Termination or extension lines mark the exact points between which the measurements are made. An extension line is a light unbroken line drawn from near (not touching) the main line of the drawing to slightly past the point of the arrow-head.

*Figures*

(1) The middle of the whole number and the dividing line of the fraction should be level with the dimension line.

(2) The dividing line of the fraction should be horizontal, not sloped.

(3) All numbers should read either from the bottom or the right-hand end of the sheet.

Note-For reference only. Not to be drawn.

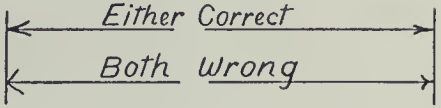
# Dimensioning.

Figures

$2\frac{3}{4}$" not 2¾"

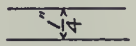
$4\frac{5}{8}$" not 4⅝"

Arrow-heads.

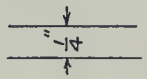



## Narrow Spaces.

Arrows only




Arrow-heads outside

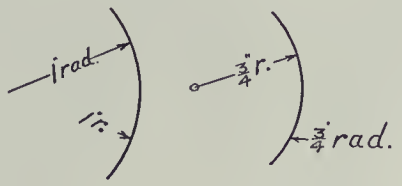



Figures in any convenient place

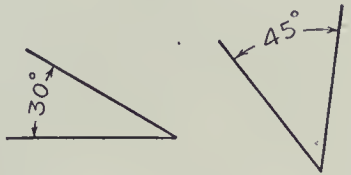
Circles.

Angles between centre lines divided evenly by dimension lines.

Arcs of circles.




Angles



PARTING TOOL Scale—Full size

*When preparing to begin* any drawing it is necessary to decide (1) how many views are to be shown, (2) the position of each, and (3) the space each will require. To see whether the arrangement decided upon is satisfactory, *lightly* sketch in rectangles of the size that the views are to be. If this is not done before beginning the drawing, it may be found that the views will not fit the space available or that the completed sheet will not look evenly balanced.

In drawing the parting tool:

(1) The front elevation should be drawn first. In any drawing the most important view or the central view should be *begun* first. Very often it is necessary then to keep all going together.

(2) The plan should be drawn *above* the front elevation and the right-end elevation to the *right* of it.

Dimension carefully, following the instructions on page 20.

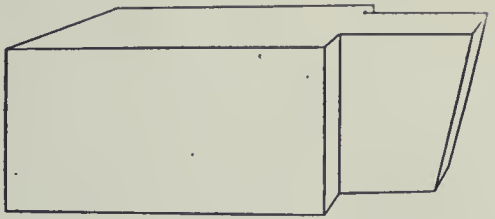
*Title.*—For the position of the title and what it should show, see pages 15 and 17.

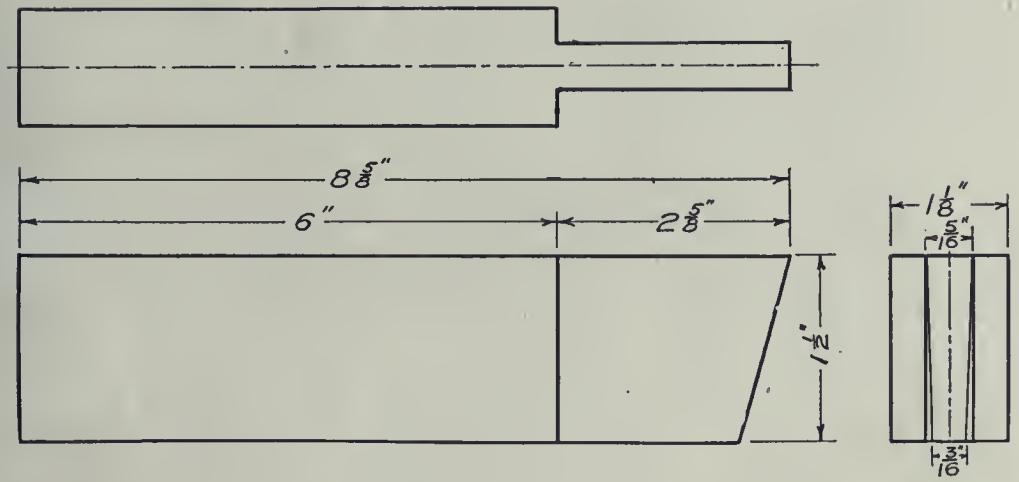
---

*Note to the Teacher*

In the arrangement of the views, the most common American practice is to place the plan above the front elevation. This is the logical arrangement and has been followed in the explanations on pages 10 to 13. An exception is usually made in drawings of single objects where three views are shown, because such an arrangement (1) leaves a blank space in the upper right-hand corner of the plate, and (2) crowds the title space in the lower right-hand corner. In drawings where only two views, or a number of views of different parts, are shown, this difficulty is not encountered.

To avoid confusing the students, it seems advisable in this simple course always to place the plan above the front elevation.




8 5/8"
6"
2 5/8"
1 1/2"
1 1/8"
5/16"
3/16

CAST-IRON WEIGHT FOR SAFETY VALVE Scale—Half size

Draw the front and end elevations and also the plan of the weight. In this case the left-end elevation is shown and is placed in its logical position—to the left.

The scale is to be half size (scale one-half or 6″ = 1′). This means that each line in the drawing must be exactly one-half the length of the line in the object that it represents.

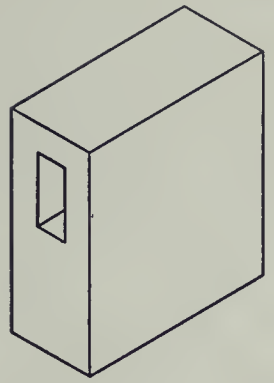
In dimensioning any drawing the dimensions must be *the true dimensions of the object to be made,* no matter what the scale of the drawing may be.

*Invisible or hidden lines.*—If, in a view, a surface not in sight must be shown, it is indicated by broken or dotted lines. These lines, in common practice, consist of 1/8″ dashes with 1/16″ spaces between and are lighter than the full object lines of the drawing. (See page 17.)

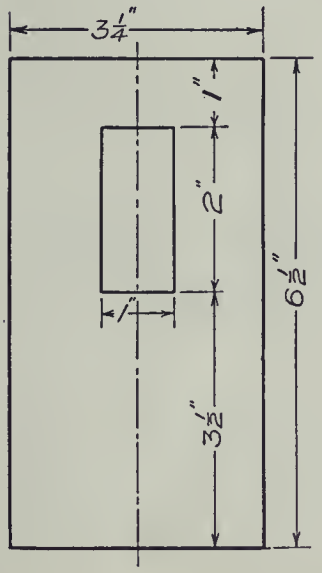
In this drawing the rectangular hole for the lever to pass through should be shown by broken lines in the front elevation and in the plan.

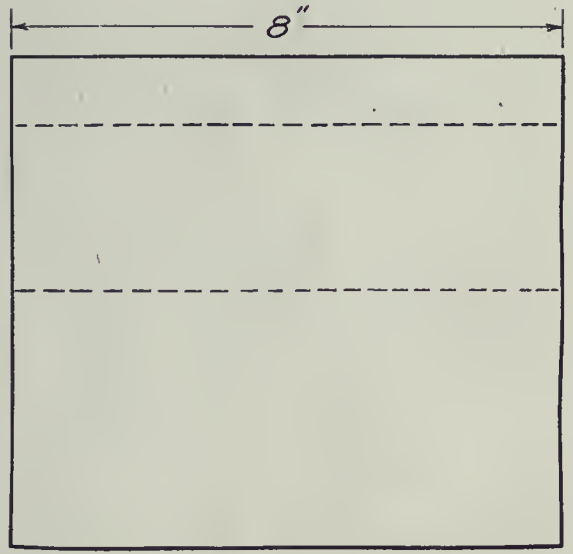
---

*To the teacher.*—The tapped hole and set-screw should be omitted from the drawing.



Plan Here



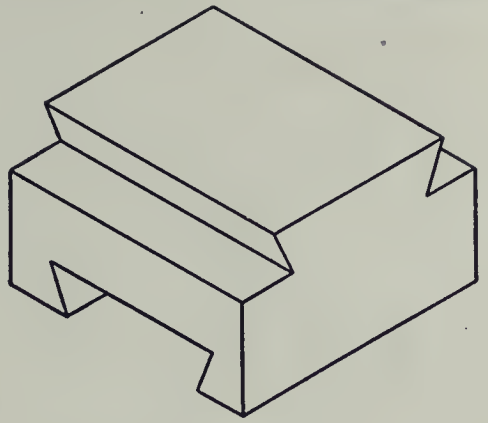



TOOL SLIDE OR SADDLE FOR LATHE Scale—Half size

Draw the front elevation as shown, and the plan, and complete the end elevation.

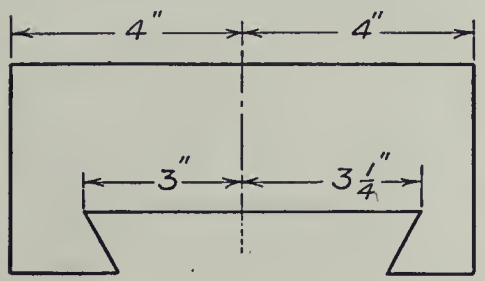
The 60° angles are obtained from the set square.

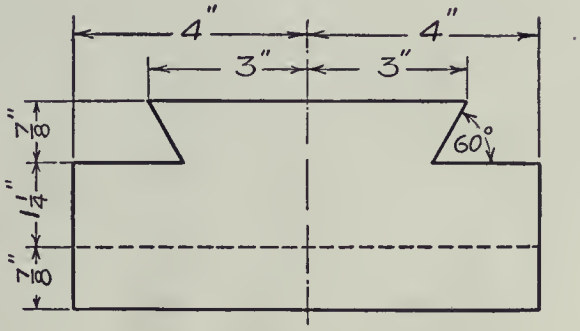
In drawing the plan, broken lines must be used as explained on page 24.



Plan here.

Complete this view.



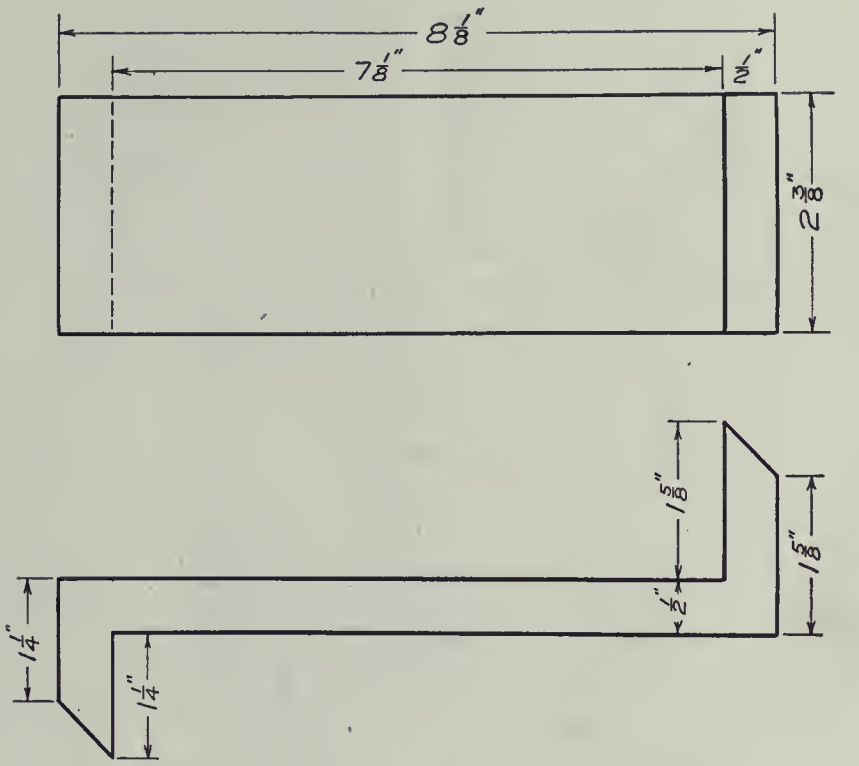



FLANGED IRON PLATE Scale—Half size

Draw the top view (plan) and elevation to scale, and also the bottom view and the two end views.

The two views shown give all the information necessary for making the plate. The other three views are to be drawn for practice in simple projection and in the use of broken lines to show hidden surfaces.

All the dimensions required are shown on the two views given.


8 1/8"
7 1/8"
1/2"
2 3/8"
1 5/8"
1 5/8"
1/2"
1 1/4"
1 1/4"

GIB KEY Scale—Full size

Show three views of a gib key about 6 inches long, making the drawing entirely from freehand sketches of the object.

---

*Drawing from the Object*

A number of exercises similar to the above are given in this course. In general, freehand sketching and drawing from the object is the best means for the beginner to obtain training in mechanical drawing. Besides, it gives the student, early in his course, the ability to make sketches of parts of machines that are to be duplicated, repaired, or altered.

(1) Make a *freehand* sketch of the object, showing the necessary views. *Use a pencil only.* Take the necessary measurements from the object and dimension the sketch.

(2) Make carefully a second freehand sketch of the object, this time on the blank page of this book facing the page of instructions. *Use a pencil only.*

These two sketches will *not be to scale,* but only roughly of the right proportions, as no scale or ruler but only a pencil is used in drawing them.

(3) From the second sketch make a working drawing *to scale* in the usual way.

---

It is recommended that *the teacher* (1) impress upon the students the importance of practice in making freehand sketches, and (2) see that the sketches *are* freehand and are made *from the object* without the aid of black-board sketches.

It is necessary for the teacher to obtain as many specimens as required of the object to be drawn. Where patterns are easier to obtain they may be used. In this exercise, if suitable gib keys cannot be had, wooden models should be made.

On this page a neat freehand sketch of the gib key, including plan, front elevation, and end elevation, should be made by the student.

TEE HEAD BOLT Scale—Full size

Draw three views—the plan, and the front and right-end elevations.

*Centre Lines*

In drawing a symmetrical object (one which is the same on each side of the centre) a *centre line* is always used. Where a view is a circle, two centre lines at right angles are always drawn.

Where centre lines are required, they should *always* be *the first lines* drawn. The drawings should then be "built up" around them.

They consist of long dashes with short ones or dots between. (See page 17.)

*Dimensioning*

1. Dimension full line views in preference to hidden (broken) line views, if possible.
2. Dimensions should be on the views that allow them to be close to the places they measure.
3. Dimension lines should be at least one-quarter of an inch from the main lines of the drawing.
4. Do not put dimensions on the centre lines if it can be avoided.
5. In a circle the dimension lines should divide the angles between the centre lines into equal parts. (See page 21.)

*The Compass*

Use the same grade of lead in the bow (small) compass that is used in the pencil. Use it also in the large compass, unless such hard lead is found to make the compass legs spread. Sharpen the lead on the outside only, so as to form a chisel edge on the inside.

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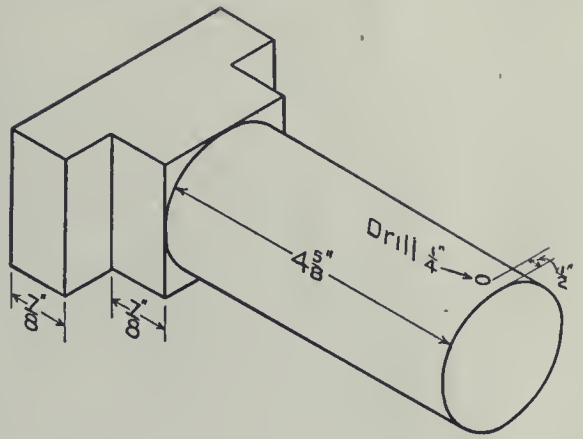
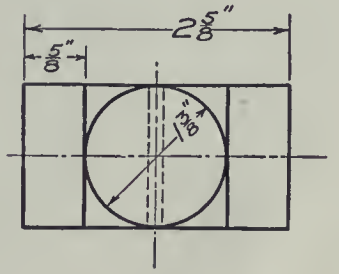
*The teacher* should see that from this point onward in *single piece* sketches or drawings the students note in a conspicuous place on each drawing the number of pieces required and the material from which they are to be made.




4-Wrought Iron



BRONZE BUSH FOR BEARINGS Scale—Full size

Make a working drawing of the bronze bush, showing three views. In drawing the side elevation and the plan, a vertical *centre line* should be the *first line drawn.*

On the drawing, close to one of the views, the letters "F. A. O.", or the words "Finish all over" or "'f' all over", should appear. Examples of such notes are shown on pages 47 and 51. These mean that all the surfaces are to be machined to the exact dimensions shown. Where these words appear, the pattern-maker or the blacksmith must allow "extra stock", usually 1/16 in. on each surface of a small object.

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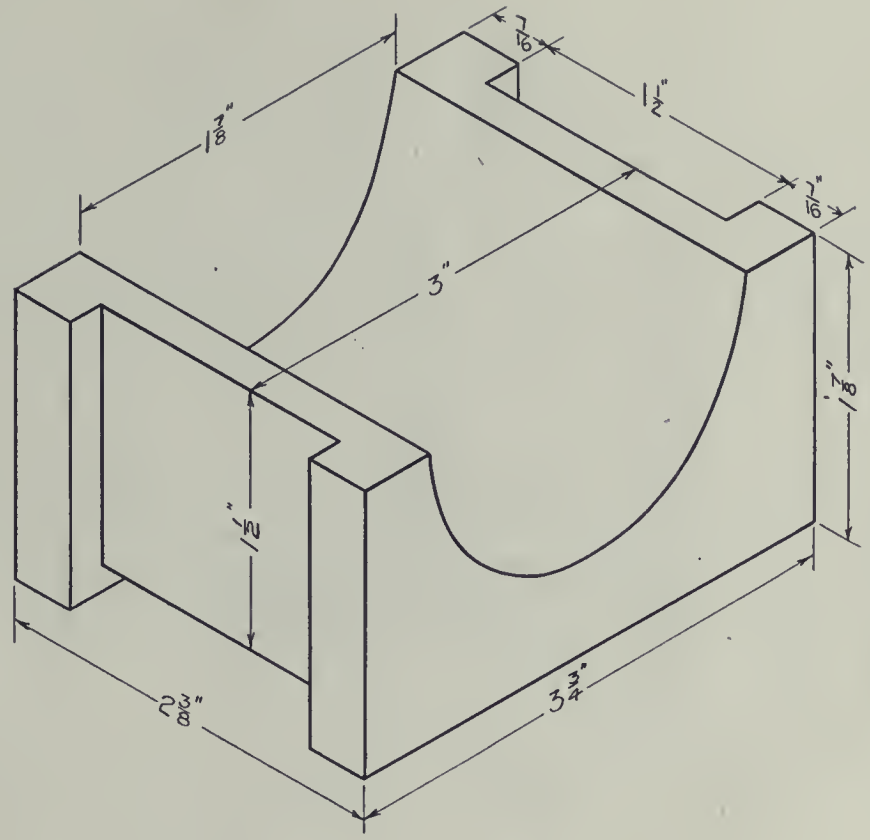
*The teacher* should see that from this exercise onward the students put all the necessary finish marks on their sketches and drawings.


7/16
1 1/2"
1 7/8"
7/16"
3"
1 7/8"
1 1/2"
2 3/8"
3 3/4"

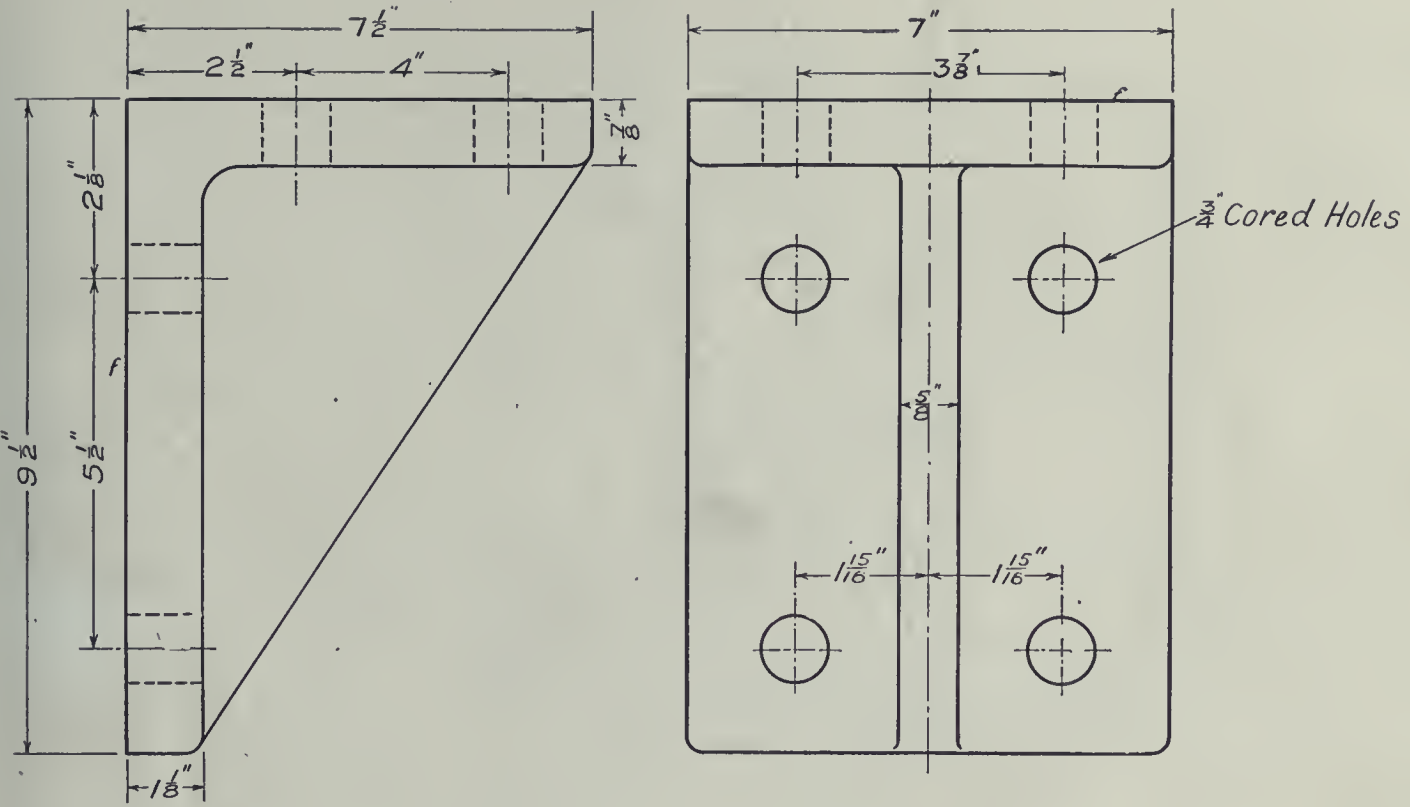
CAST-IRON BRACKET Scale—Half size

Make a drawing of the bracket *to scale*. Two views are sufficient.

In castings where two unfinished surfaces meet at an abrupt angle, the corners are always rounded by *fillets*. These are shown in drawings by short curved lines. The radii of the fillets are sometimes given in drawings. This is not necessary, as the pattern-maker knows what size they should be.

In a *pencil* drawing, where straight lines are joined by curves the straight lines are *always* drawn first.

The mark, "f", "F", or "Fin.", on or close to a line shows that the flat surface the line represents is to be finished or machined to the dimension shown in the drawing. The finish mark most commonly used is "f", as shown in this drawing. Where such mark appears, the pattern-maker or blacksmith must leave extra stock. The dimensions on a working drawing of a piece that is to be machined are those of the machinist's product, the finished object, not those of the piece as it leaves the hands of the blacksmith or foundryman.


7½"
2½"
4"
⅞"
2⅛"
9½"
5½"
1⅛"
7"
3⅞"
¼" Cored Holes
⅝"
1 15/16"
1 15/16"

### Drawing from the Object

Make freehand sketches and a working drawing (the latter to a suitable scale) of *any one* of the following:

Valve rocker arm
Rectangular valve (steam) chest cover
Plain cylinder cover for rear end
Bearing cap
Solid bearing box
Journal brasses

Read carefully the instructions given on page 30.

---

*The teacher* should, in all the exercises in freehand sketching from the object, impress on the students the importance of this part of the work, and see that its purpose is carried out. (See page 30.

The object chosen from the above list should be of one piece only and have no tapped holes or threads. It should be so simple in form that a section is unnecessary.

The teacher should have available, for the use of the students in taking measurements from objects, inside callipers, outside callipers, and protractors.

On this page the student should make, *from the object,* a freehand sketch of a machine part selected from the list on page 38.

## Inking In and Tracing

In night school classes it is not advisable to take up much of the students' time with inking in and tracing. None should be done until the last two months of the night school year. Then two plates should be inked in and two tracings from others made, not more than one-third of the two months being taken up with this work.

In day school classes, as the students' time is not so limited, more attention should be given to this part of the work.

Read carefully the following instructions, refer to them frequently, and follow them as closely as possible:

Pencil drawings that are to be traced or inked in should be very carefully made, so that all the lines may be followed exactly with the drawing pen; the doing of careless pencil work to be corrected in the inking is a wrong policy, as defects in the inking are sure to result, making necessary erasures that will spoil the appearance of the drawing.

*All curved lines* should be inked in or traced first. When there are a number of circles and arcs of the same diameter, they should all be inked in one after another so that the setting of the compass need not be altered. Where there are concentric circles, the smallest ones should be inked in first.

*All* light curved lines should be inked in before the heavy ones.

Ink in or trace circles and curves first and in the following order: (1) invisible (hidden) circles and curves, (2) construction circles and curves, (3) circular centre lines (bolt circles), (4) dimension arcs of angles, and (5) visible circles and curves.

Ink in straight lines last and in the following order: (1) invisible straight lines, (2) construction straight lines, (3) straight centre lines, (4) dimension lines and termination lines, (5) visible straight lines, (6) figures and lettering, and (7) section lines or cross-hatching *last.*

Ink in similar horizontal lines using a set-square, starting at the top of the sheet, and taking all in the order in which they come. Ink in, similarly, the vertical lines, starting with the one farthest to the left.

In using the compass pen, bend the joints of both legs so that the needle point and the pen will both be perpendicular to the paper. In using the drawing pen, (1) adjust it carefully so that the thickness of the lines will be the same as that of corresponding lines made by the bow and compass pens, and (2) hold it so that it will be almost perpendicular, the only inclination being to the right (in the direction the line is being drawn). Before starting to draw a new weight of line, make trial lines on a scrap of drawing paper (or tracing linen), adjusting the pen until the desired weight is reached.

Do not have ink on the outside of your pen.

Do not leave your ink-bottle standing open, or where it may be upset upon your drawing.

Do not ink your pen over your drawing; you may drop some ink.

Do not put your pen away without carefully wiping it and releasing the spring.

Make your drawing or tracing *a good, bold weight.* It will look better.

For letters, figures, arrow-heads, etc., use a writing pen that is not too sharp, such as Gillott's 404. For titles use a Falcon pen. Have little ink on the pen. Use an even pressure throughout each stroke. In lettering, draw light pencil lines *on the linen* to keep the height even. Do not try to trace the lettering or guide yourself by lines on the drawing you are tracing.

Either side of the tracing linen may be used. Rub it over well with powdered chalk or, better, finely ground pumice. Inking can be more easily done on the rough side. If erasures are likely to be necessary, the smooth side should be used.

SETTLING BOX WITH BAFFLE Scale—1½ in. = 1 ft.

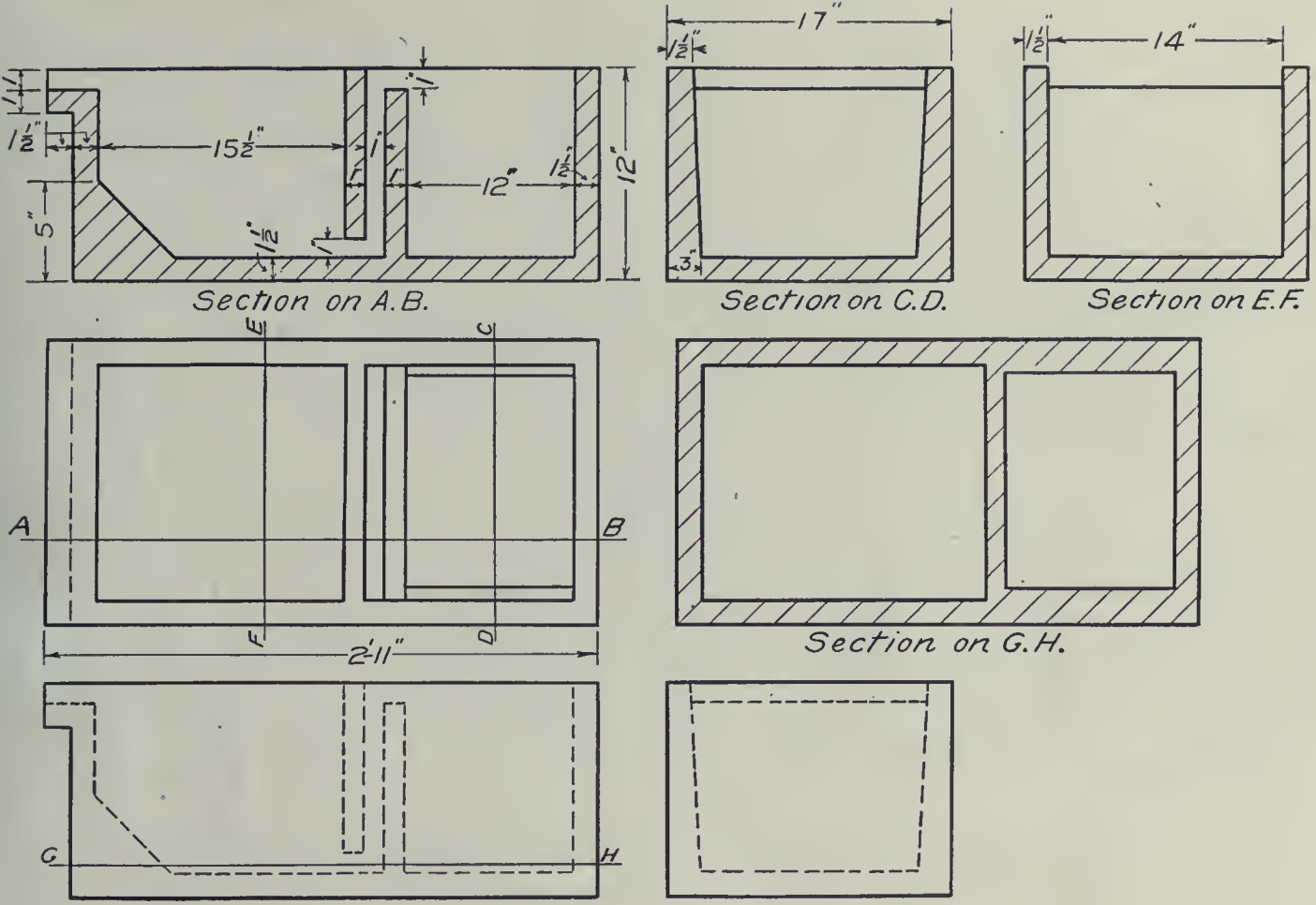
The student is familiar with the use of broken lines to show hidden surfaces. Very often a drawing can be made much simpler and be more easily understood by showing *sections* of the object than by using broken lines. In a section the object is drawn with part cut away so that the interior is shown.

To indicate that the drawing is a section, the new surfaces exposed by the cutting are marked with *section-lines* or *cross-hatching*. Where only one material is shown in section, the cross-hatching is that shown for cast iron on page 45, no matter what the material may be, the material being specified as usual on the drawing. In cross-hatching, light lines sloped at 45° are used. The distance the lines are apart depends on the size of the drawing. Do not have them too close together; and space them by the eye only.

Draw the box to scale. In addition to the usual plan, front elevation, and end elevation, four sections are shown. If the box were cut in two at the place indicated by the line AB in the plan and one of the two parts were looked at from directly in front of the new surface produced by the cutting, the view obtained would be that shown in the "section on AB". The other three sections represent respectively views that would be obtained if the box were cut through at the places indicated by the lines CD, EF, and GH.

To know what surfaces to cross-hatch, think of the cross-hatchings as being the marks left by the teeth of the saw.

*Dimensioning.*—Where there is no room for figures and arrow-heads, the arrow-heads may be placed outside the space dimensioned instead of inside, and the figures in any convenient position. Examples of these occur on the opposite page. See also page 21.


1½"
1½"
15½"
1"
1"
1"
1"
12"
1½"
12"
5"
1½"
1"
Section on A.B.
17"
1½"
3"
Section on C.D.
1½"
14"
Section on E.F.
E
C
A
B
F
D
2'-11"
Section on G.H.
G
H

## Sectioning

Conventional cross-hatchings or section lines used to indicate different materials are shown on page 45. Unfortunately these are not standardized, different draughting offices using entirely different systems of section lining.

Where only one material is used, no matter what it may be, it is represented by the conventional sectioning for cast-iron.

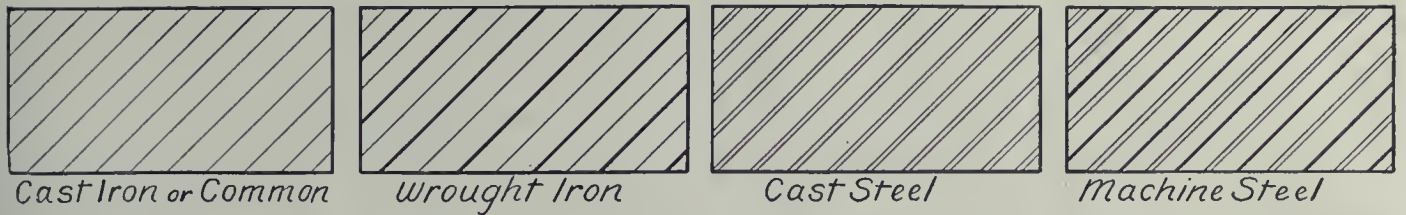
The following instructions regarding sectioning are important:

1. Section lines are light lines *evenly spaced and sloped at 45°.*
2. Spacing should not be close and must be done without measuring.
3. Bolts, shafts, keys, screws, etc., *are not* shown in section when they lie lengthwise in the plane of the section; when they are cut crosswise by the section they *are* shown in section.
4. Dimension lines, extension lines, etc., must not be drawn across the section lines of a view if they can be placed elsewhere.
5. *The dimensioning must be finished before the cross-hatching is begun.*
6. In an assembly section (that is, a section showing a number of different pieces) each piece must have the same cross-hatching throughout, all the lines on it being drawn in the same direction and each completed for the total width of the piece at one drawing. The section lines of pieces in contact must, if possible, be at abrupt angles to each other, usually at right angles.

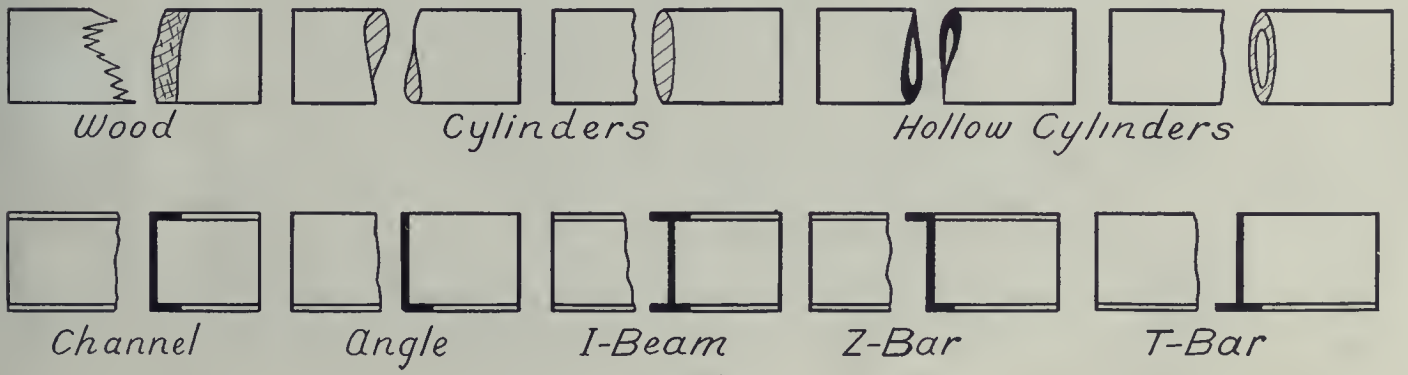
Note.—In some draughting offices, because of the saving in the draughtsmen's time, only plain cross-hatching (that shown for cast iron on page 45) is used. Whether the materials are indicated by the section lining or not, it is *always necessary* to state clearly in words what materials are to be used. In a drawing of a single piece the material is usually specified in a prominent place beside one of the views; in a detailed drawing of a number of parts, in the "bill of material" above the title.

Note:- For reference only. Not to be drawn.

## Conventional Cross-Sections.




## Conventional Breaks

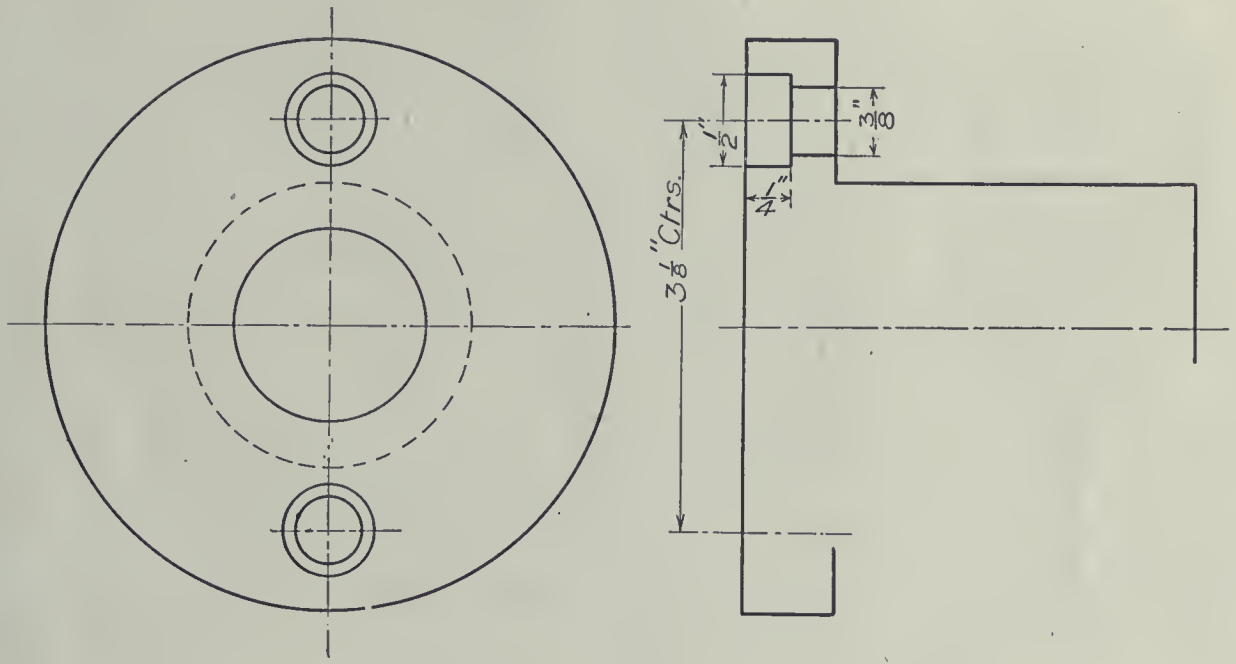


FLANGED BUSHING Scale—Full size

Draw the end elevation and complete the longitudinal section, both to scale.

The bushing is to be made of brass and is to be of the following dimensions: Length over all, 4 in.; diameter of flange, 4 1/8 in.; thickness of flange, 1/2 in.; outside diameter of bushing, 2 1/8 in.; inside diameter, 1 1/16 in.

In drawing the section follow carefully the instructions regarding the section-lines given on pages 42 and 44.




F.A.O.

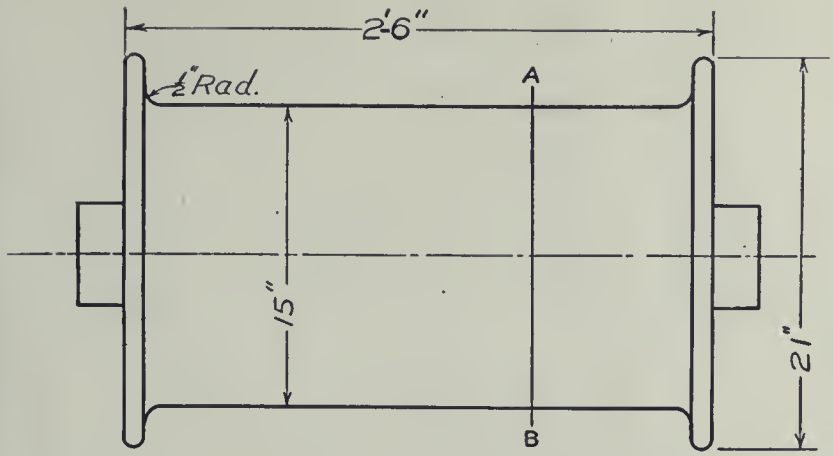
DRUM FOR WINCH Scale—1½ in. = 1 ft.

Draw the two views shown, and also an end elevation, and a section at AB. No broken lines are necessary in this drawing.

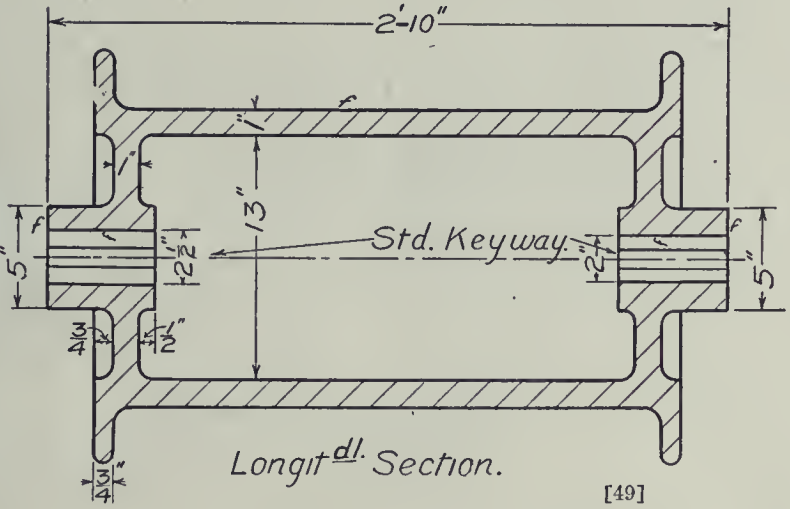
Draw the centre lines first, then (1) the end elevation, (2) the side elevation, and (3) the sections.

This is a good example of the use of sections. The form of the drum could not be shown by any other means.

*Standard keyway.*—The width is one-quarter the diameter of the shaft; the depth, one-half the width.




Draw End Elevation Here.




Longit^dl. Section.

Draw Transverse Section at A.B. Here.

STUFFING BOX GLAND AND BUSHING Scale—Full size

Draw the two views to scale from the sketches shown. As *always* in making a symmetrical drawing, *draw the centre lines first.*

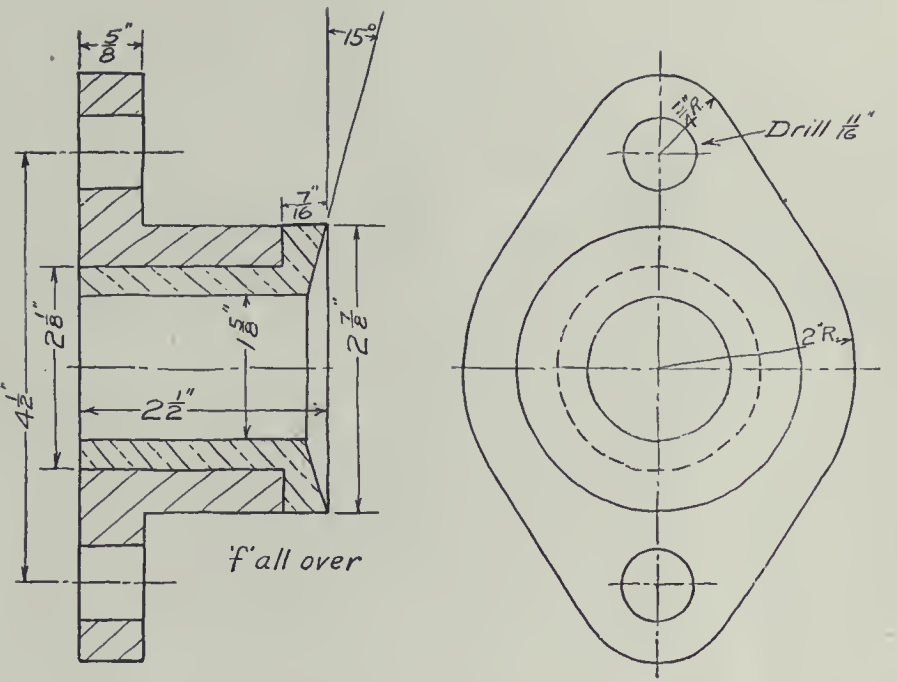
In the section—

1. Only the new surfaces produced by the supposed cutting are cross-hatched; the bolt holes and the bearing surface of the bushing are not hatched.

2. The section-lines, or hatching, on the drawing of one piece of material are exactly alike and drawn in the same direction; notice the two edges of the gland and the two edges of the bushing.

3. The surfaces of two different pieces in contact have the section lines at an abrupt angle (usually right angles) to each other; notice where the gland and the bushing are in contact.

4. Different materials in section in one drawing are usually designated by conventional hatchings (see pages 44 and 45); here the hatching shows that the flange is to be cast iron and the bushing brass or bronze.


5/8"
15°
7/16"
4 1/2"
2 7/8"
1 5/8"
2 1/2"
f' all over
1 1/4" R
Drill 11/16"
2" R

### Drawing from the Object

Make a freehand sketch of any one of the following. From the sketch make a working drawing, showing the necessary views and sections, *to a suitable scale.*

Gear blank
Solid pulley
Shaft collar

Follow carefully the instructions given on page 30.

In the above space a freehand pencil sketch of one of the three objects mentioned on page 52 should be made by the student. The views should be similar to those of the stuffing box gland and bushing on page 51.

BUTT COUPLING Scale—Half size

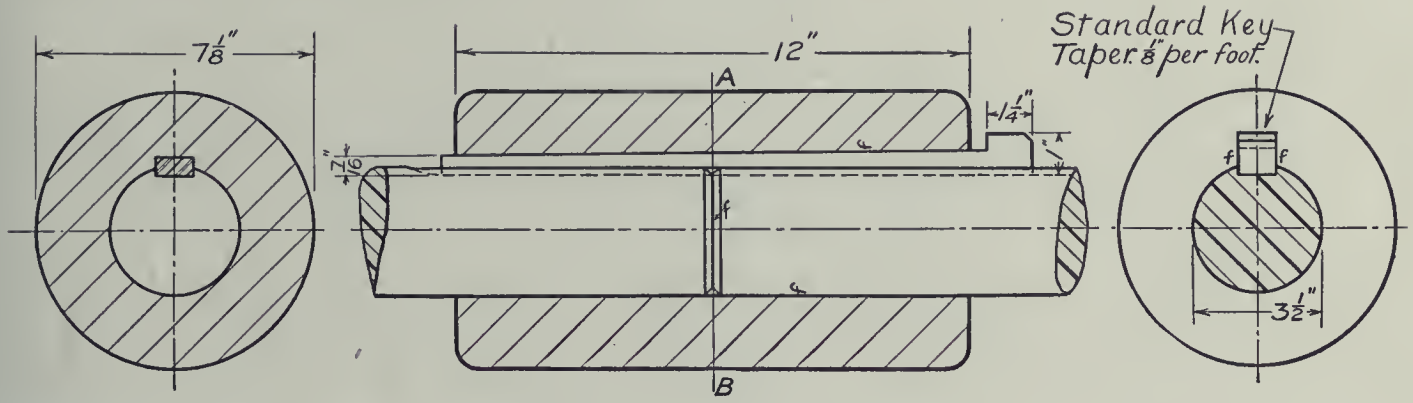
This drawing shows the ends of two shafts joined by a butt coupling, three views being given—a transverse section through the middle, a *longitudinal* section, and an end elevation.

The section lines show that the coupling is to be cast iron; the shafts, wrought iron; and the key, steel. A short note is sometimes used instead of this conventional hatching.

Two conventional methods of showing breaks in shafts or other parts too long to draw in full are shown.

A short, plainly expressed note may often be used to advantage to make a point in the drawing clear.

For the dimensions of standard keyways see page 48.




Section on A.B.

## Threads, Bolts, and Nuts

The page facing this one shows (1) the forms of the most common types of threads and their uses, (2) the conventional forms ordinarily used to represent them in drawings, and (3) a simple method of drawing bolts and nuts.

### *Threads*

1. The *nominal diameter* of a screw is its diameter outside the threads.
2. The *root* or *effective diameter* is the diameter at the bottom of the threads.
3. The *pitch* is the distance from the centre of one thread to the centre of the next.
4. The *lead* is the distance a nut advances in one complete turn.

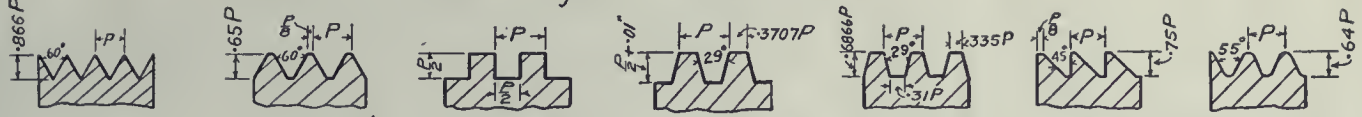
### *Conventional Threads*

The first three shown are commonly used for ordinary threads. The second and third are the most frequently used, as they are easily drawn. Threads for nuts are shown in broken line and by means of sections. Notice that *in the section the farther side of the threads are shown,* and therefore the lines representing them must slant in the direction opposite to that on the bolts.

### *Bolts and Nuts*

A simple method of drawing these is shown. This does not give a form that is correct according to the table on page 59, but the result is close enough for practical purposes in drawing small bolts.

Note:- For reference only  Not to be drawn.




V-Thread — Bolts, Studs and Capscrews

U.S.Stand$^{d}$. — Bolts, Studs and Capscrews

Square — Jacks, Presses, Valve Spindles.

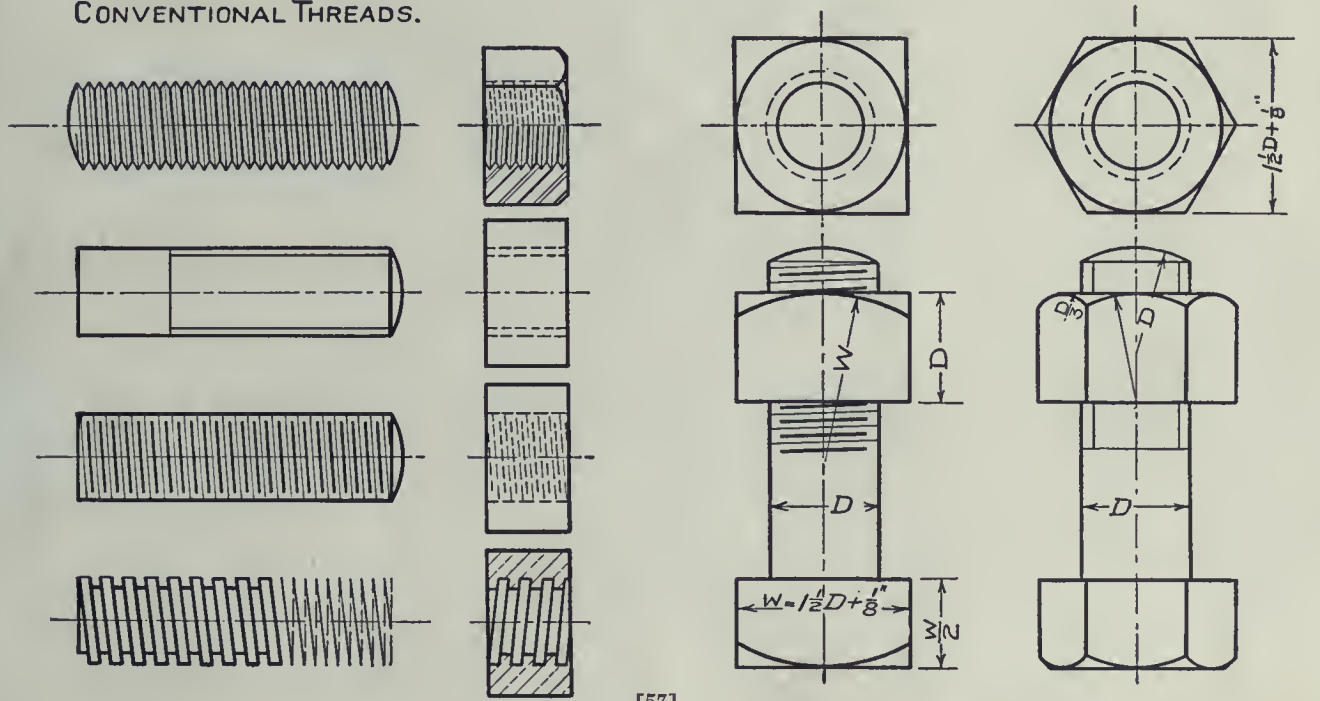
Acme — Feed Screws on lathes, etc.

Worm Gas. — Worm Gears.

Buttress — Vises, Lathes, Gun Racks.

Whitworth — British Standard.

## CONVENTIONAL THREADS.



## Decimal Equivalents

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1. | 1/32 | .0313 | 1/64 | .0156 | 33/64 | .5156 |
| 1/2 | .5 | 3/32 | .0938 | 3/64 | .0469 | 35/64 | .5469 |
| 1/4 | .25 | 5/32 | .1563 | 5/64 | .0781 | 37/64 | .5781 |
| 3/4 | .75 | 7/32 | .2188 | 7/64 | .1094 | 39/64 | .6094 |
| 1/8 | .125 | 9/32 | .2813 | 9/64 | .1406 | 41/64 | .6406 |
| 3/8 | .375 | 11/32 | .3438 | 11/64 | .1719 | 43/64 | .6719 |
| 5/8 | .625 | 13/32 | .4063 | 13/64 | .2031 | 45/64 | .7031 |
| 7/8 | .875 | 15/32 | .4688 | 15/64 | .2344 | 47/64 | .7344 |
| 1/16 | .0625 | 17/32 | .5313 | 17/64 | .2656 | 49/64 | .7656 |
| 3/16 | .1875 | 19/32 | .5938 | 19/64 | .2969 | 51/64 | .7969 |
| 5/16 | .3125 | 21/32 | .6563 | 21/64 | .3281 | 53/64 | .8281 |
| 7/16 | .4375 | 23/32 | .7188 | 23/64 | .3594 | 55/64 | .8594 |
| 9/16 | .5625 | 25/32 | .7813 | 25/64 | .3906 | 57/64 | .8906 |
| 11/16 | .6875 | 27/32 | .8438 | 27/64 | .4219 | 59/64 | .9219 |
| 13/16 | .8125 | 29/32 | .9063 | 29/64 | .4531 | 61/64 | .9531 |
| 15/16 | .9375 | 31/32 | .9688 | 31/64 | .4844 | 63/64 | .9844 |

# Dimensions of U.S. Standard Bolts, Heads and Nuts.

## Rough

| Dia. of Bolt. | No. of Thrds per inch | Across Flats of Heads & Nuts | Across Corners of Heads & Nuts. | | Thickness Hex. & Square. | | Dia. of Tap drill. | Dia. at root of Thread. |
|---|---|---|---|---|---|---|---|---|
| | | Hex & Square | Hex. | Square. | Heads | Nuts. | | |
| | | | | | | | | |
| 1/4 | 20 | 1/2 | 37/64 | 23/32 | 1/4 | 1/4 | 13/64 | .185 |
| 5/16 | 18 | 49/32 | 11/16 | 27/32 | 19/64 | 5/16 | 1/4 | .240 |
| 3/8 | 16 | 11/16 | 51/64 | 31/32 | 11/32 | 3/8 | 5/16 | .294 |
| 7/16 | 14 | 25/32 | 29/32 | 1 7/64 | 25/64 | 7/16. | 23/64 | .344 |
| 1/2 | 13 | 7/8 | 1 1/64 | 1 1/4 | 7/16 | 1/2 | 27/64 | .400 |
| 9/16 | 12 | 31/32 | 1 1/8 | 1 3/8 | 31/64 | 9/16 | 15/32 | .454 |
| 5/8 | 11 | 1 1/16 | 1 15/64 | 1 1/2 | 17/32 | 5/8 | 17/32 | 507 |
| 3/4 | 10 | 1 1/4 | 1 29/64 | 1 25/32 | 5/8 | 3/4 | 41/64 | .620 |
| 7/8 | 9 | 1 7/16 | 1 43/64 | 2 1/32 | 23/32 | 7/8 | 3/4 | .731 |
| 1 | 8 | 1 5/8 | 1 7/8 | 2 19/64 | 1 3/16 | 1 | 55/64 | 837 |
| 1 1/8 | 7 | 1 13/16 | 2 3/32 | 2 9/16 | 29/32 | 1 1/8 | 31/32 | .940 |
| 1 1/4 | 7 | 2 | 2 5/16 | 2 53/64 | 1 | 1 1/4 | 1 3/32 | 1.065 |
| 1 3/8 | 6 | 2 3/16 | 2 17/32 | 3 3/32 | 1 3/32 | 1 3/8 | 1 13/64 | 1.160 |
| 1 1/2 | 6 | 2 3/8 | 2 3/4 | 3 23/64 | 1 3/16 | 1 1/2 | 1 21/64 | 1.284 |
| 1 3/4 | 5 | 2 3/4 | 3 3/16 | 3 57/64 | 1 3/8 | 1 3/4 | 1 17/32 | 1.491 |
| 2 | 4 1/2 | 3 1/8 | 3 39/64 | 4 27/64 | 1 9/16 | 2 | 1 3/4 | 1.712 |
| 2 1/4 | 4 1/2 | 3 1/2 | 4 3/64 | 4 61/64 | 1 3/4 | 2 1/4 | 2 | 1.962 |
| 2 1/2 | 4 | 3 7/8 | 4 31/64 | 5 31/64 | 1 15/16 | 2 1/2 | 2 7/32 | 2.176 |
| 2 3/4 | 4 | 4 1/4 | 4 29/32 | 6 1/64 | 2 1/8 | 2 3/4 | 2 15/32 | 2.426 |
| 3 | 3 1/2 | 4 5/8 | 5 11/32 | 6 17/32 | 2 5/16 | 3 | 2 11/16 | 2.629 |

BOLTS AND NUTS Scale—Full size

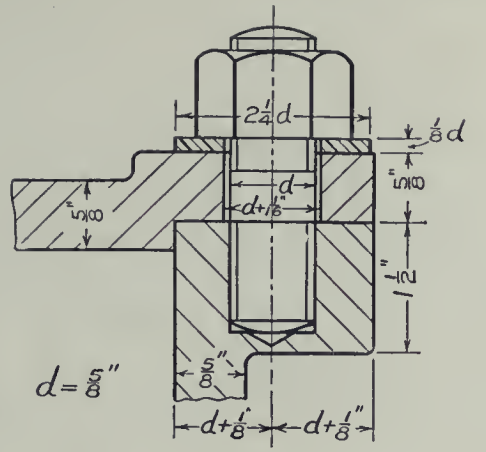
In making each of these drawings—

1. Draw the whole in outline.
2. Complete the bolt and nut.
3. Dimension.
4. Cross-hatch.

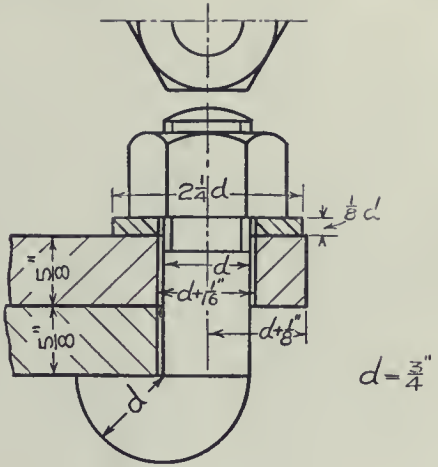
Draw the bolt head and nuts according to the diagram on page 57.

Certain dimensions in two of the drawings depend on and are obtained from the diameter of the bolt ($d$).

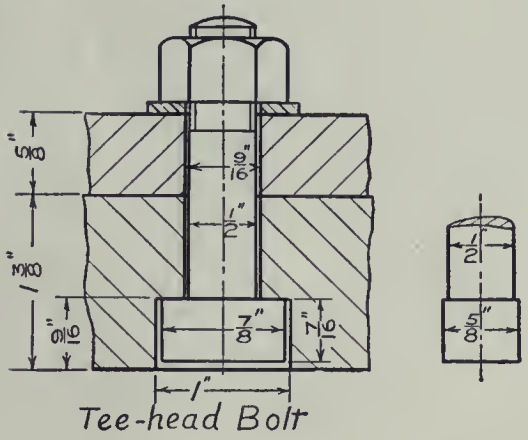
In a section, bolts, shafts, keys, etc., when shown *lengthwise,* are not cross-hatched; if the section cuts *across* them they are cross-hatched.



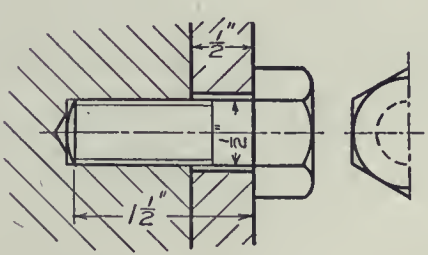

Stud-bolt




Hook-bolt




Tee-head Bolt




Tap-bolt or Cap-screw

### Drawing from the Object

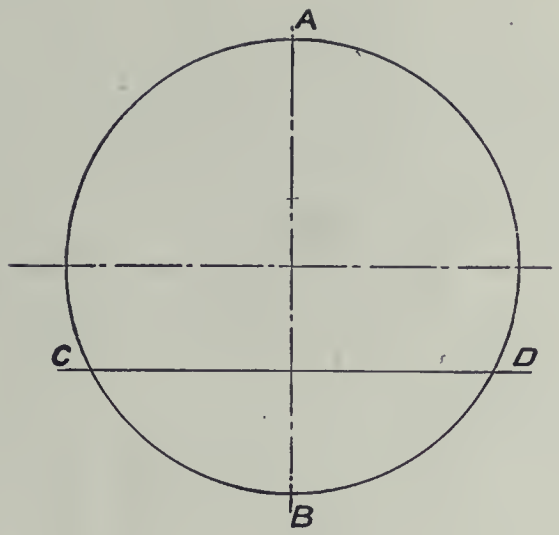
Draw to a suitable scale, *from a sketch made from the object,* a front view and two sectional views of any one of the following: face plate, eccentric sheave, mushroom valve, or any other simple disc-shaped part of a machine. The front (circular) view should be drawn first and the sections projected from it.

As explained on page 30, make a rough *freehand* sketch first, then a more careful *freehand* sketch on the page facing this one, and from this make a working drawing to scale. The sketches will not be to scale, but *the dimensions* on them *must be exact.*

---

*The teacher* should obtain one or more face plates from a machine shop if possible. If these cannot be obtained, a face plate from a wood-turning lathe or some other machine part of disc shape will do.

These exercises in "drawing from the object" are of little value unless the students (1) make their sketches entirely from the object, and (2) make them freehand, *using a pencil only.*




Section on line A.B. here

Section on line C.D. here

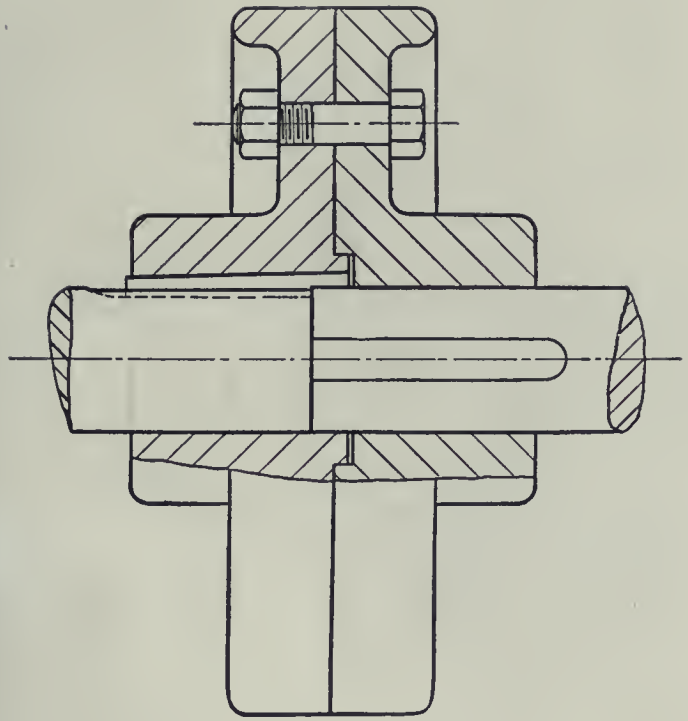
FLANGE COUPLING Scale—Half size

Draw to scale the side elevation of the flange coupling, showing the upper half in section. A drawing of a symmetrical object made in this way usually gives a better idea of the object than if the whole were shown in section. Compare the butt coupling, page 55.

Draw also the end elevation. This should be a half view only. It is a waste of time to draw a complete circular view when a half one will do as well.

The dimensions of the coupling depend on that of the shaft. In this case use the following:

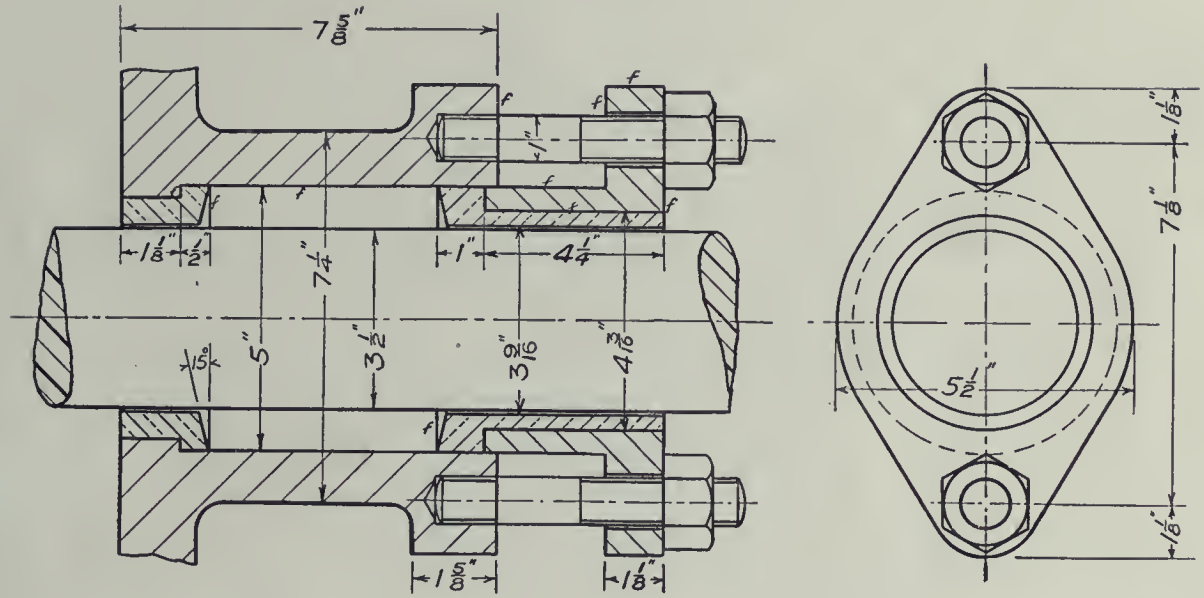
Diameter of shaft, 5½ inches
Diameter of flange, 22 inches
Thickness of guard rim, 1½ inches
Projection of guard rim, 1½ inches
Thickness of flange, 2 inches
Diameter of boss, 11 inches
Depth of boss, 7¼ inches
Number of bolts, 6
Diameter of bolts, 1¼ inches
Diameter of bolt circle, 14¾ inches
Projection of one shaft into opposite flange, ½ inch
One flange checked into other, ¼ inch
Standard keyways



End Elevation Here

STUFFING BOX Scale—Half size

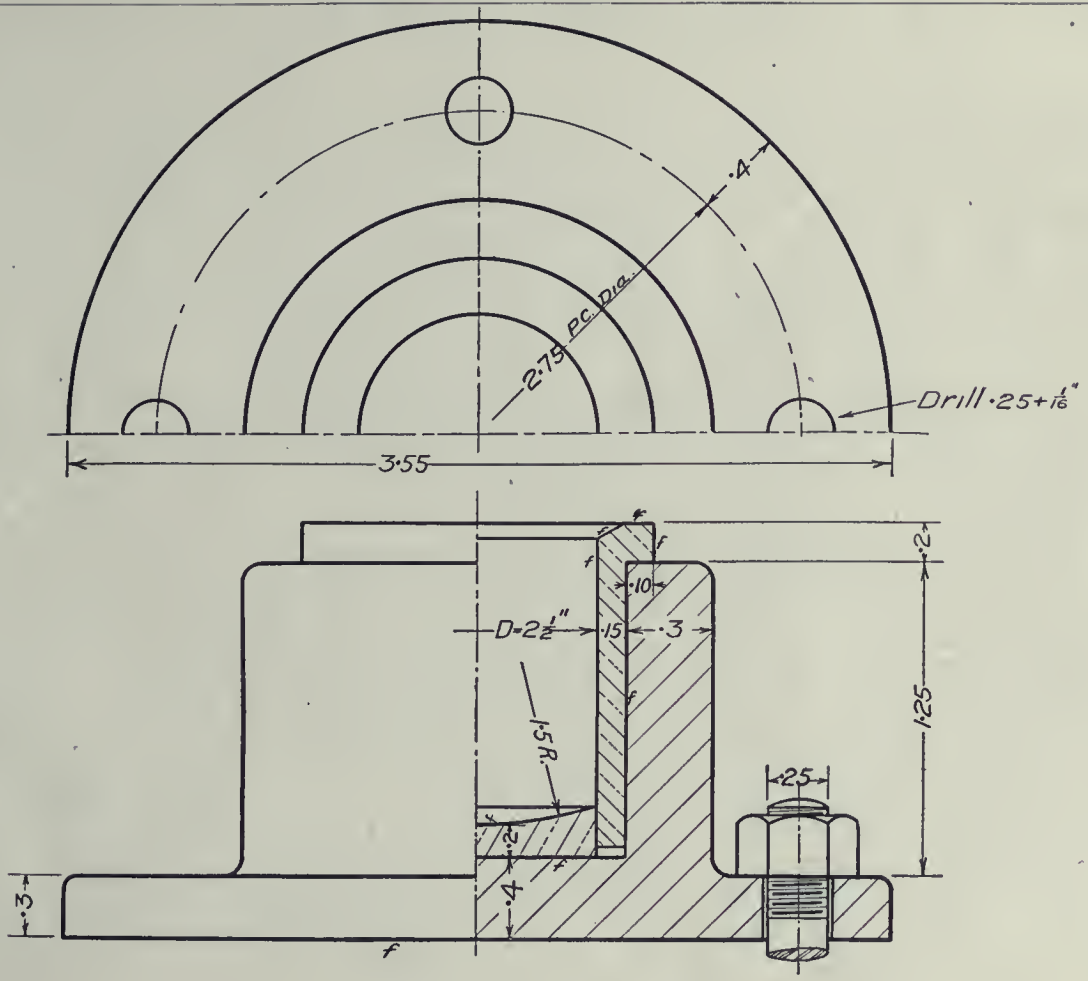
Draw to scale the stuffing box for a 3½-inch shaft as shown.


7 5/8"
1"
1 1/8"
1/2"
7 1/4"
1"
4 1/4"
5"
3 1/2"
3 9/16"
4 1/16"
15°
1 5/8"
1 1/8"
5 1/2"
1 1/8"
7 1/8"
1 1/8"

FOOT-STEP BEARING Scale—Half size

Draw the views of the foot-step bearing to scale.

The proportions of the bearing are all determined by the diameter of the shaft. In this case the diameter of the shaft is 2½ inches. The dimensions of the bearing are stated as multiples of 2.5 inches, for example, (1) the thickness of the casting directly under the bearing is given as .4—this means .4 x 2.5″ = 1″, (2) the diameter of the bolts is marked .25—this means .25 x 2.5″ = .625″. By referring to the "Decimal Equivalent Table" (page 58) .625″ is found to be 5/8″.


·4
2·75 P.C. Dia.
Drill ·25+1/16"
3·55
f
·10
D=2 1/2"
·15
·3
·2
1·25
1·5 R.
·25
·2
·4
·3

### Drawing from the Object

Make *in the shop* a carefully dimensioned freehand sketch of any one of the following. In the class-room make a second sketch and a working drawing. (See page 30.)

Large driving pulley
Hand wheel
Fly wheel

Make the second sketch mentioned on page 70 in the space above. *The teacher* should explain to the student how the cross section of one of the arms may be shown by the use of a *revolved section.*

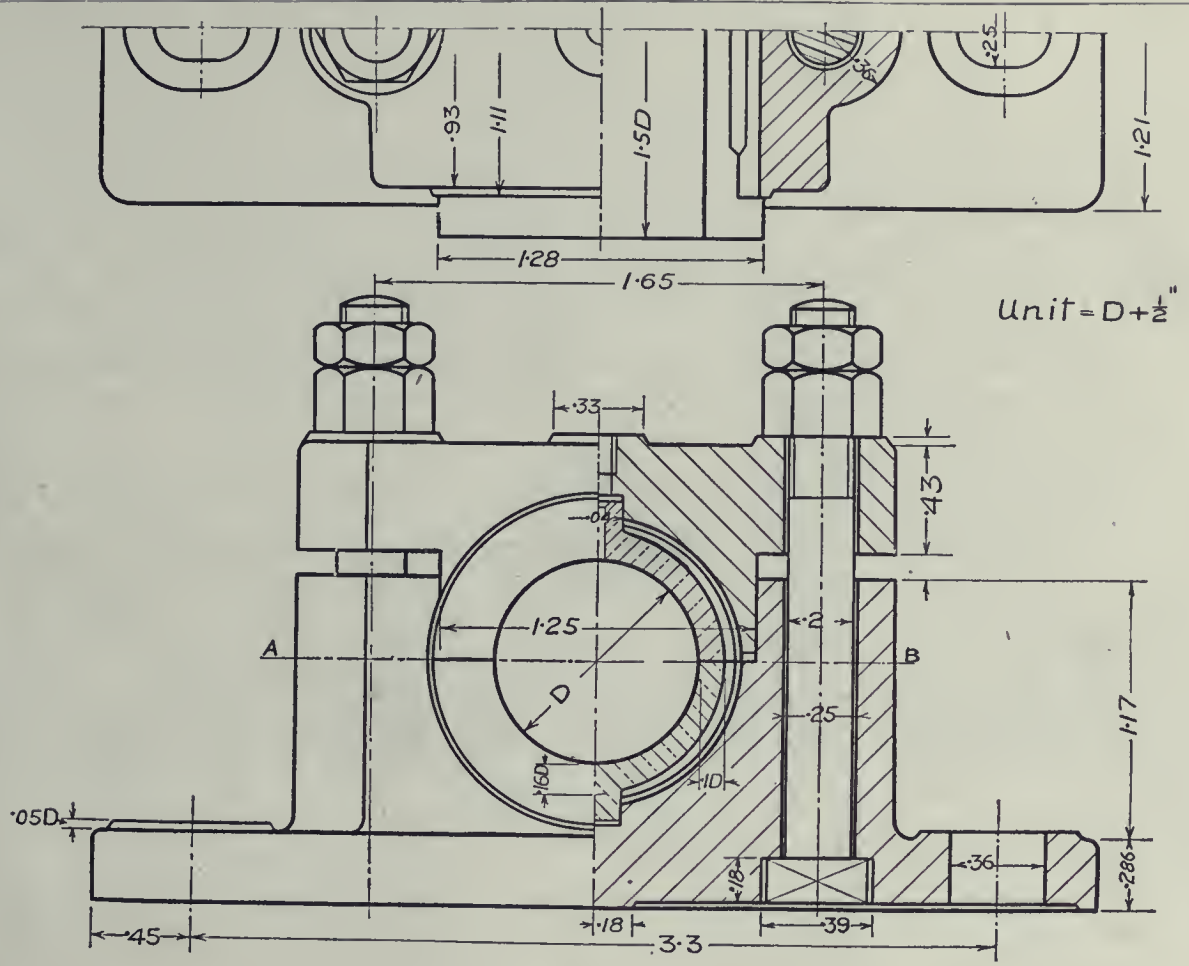
PEDESTAL OR PILLOW BLOCK Scale—Half size

Draw to scale two assembled views (plan and front elevation) of a pillow block for a 3-inch shaft, showing half of each view in section. Draw also an end elevation in full.

This assembly drawing should not be dimensioned, but the next one (pages 74 and 75), a detail drawing of the same pillow block, should be dimensioned. The dimensions are obtained from the diameter of the shaft by using the diameter plus ½ inch (D + ½″) as the unit and multiplying by the factors given, except where they are specified in terms of D only.

*Assembly and detail drawings*

A number of assembly drawings (or assembled views) have been drawn (flange and bushing, foot-step bearing, etc.), but in none of these cases have detail drawings been made by the students. In a case like this, where an assembly drawing and also a detail drawing (see also pages 76 and 77) are to be made, the assembly drawing is not to be dimensioned as the preceding ones were. Assembly drawings are intended to show merely the positions of the different parts and how they are to be put together. Detail drawings show how each part is to be made and are the *working drawings* from which the mechanics make the parts. They must be carefully dimensioned.


·93
1·11
1·5D
·25
1·21
1·28
1·65
Unit = D + ½"
·33
·43
·04
1·25
A
B
D
·2
·25
1·17
·16D
·1D
·05D
·18
·36
·286
·45
3·3
·39

PEDESTAL OR PILLOW BLOCK Scale—Half size

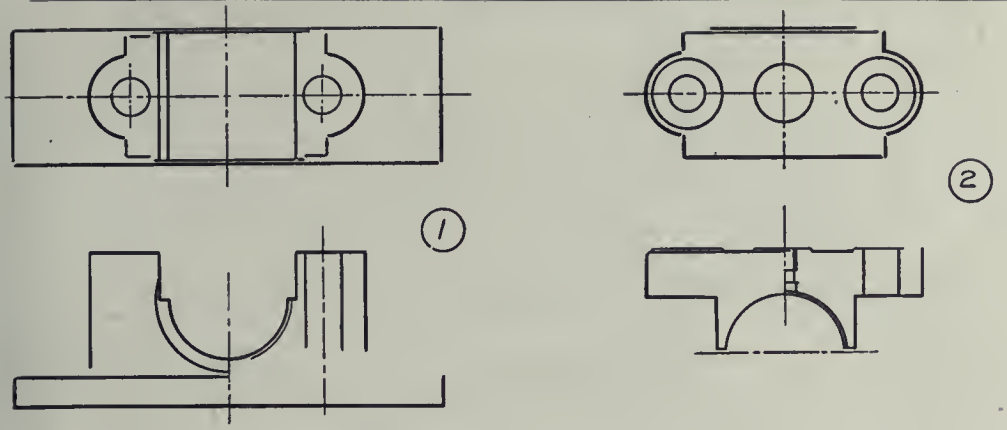
Make a set of working drawings of the pillow block (page 73)—(1) plan and side elevations of the block and the cap, (2) two views of one of the brasses, and (3) one view of a bolt.

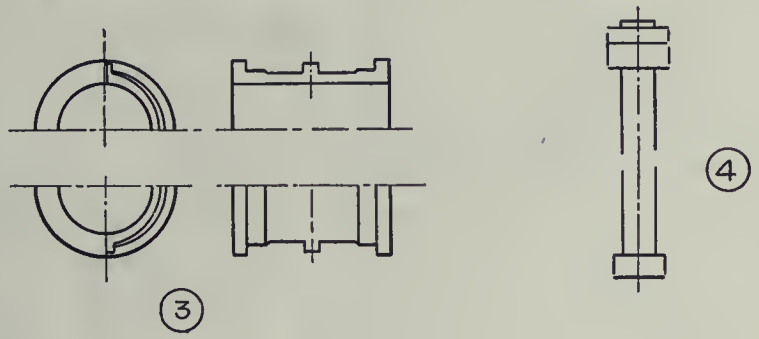
An arrangement of these views is indicated on the opposite page. In arranging detail drawings, consideration should be given to the following:

1. A properly balanced plate
2. Each part being represented turned in the position it occupies in the assembled drawing
3. The parts arranged close to related parts
4. If different scales are used, the size of the different drawings should correspond to the importance or unimportance of the parts.

Working drawings must be carefully dimensioned.

In a detail drawing each piece is numbered and a "bill of material", bearing corresponding numbers, is shown, usually above the title. On the opposite page a bill of material is made out.




| Item | Req.d | Patt.n | Description | Mat.l |
|---|---|---|---|---|
| 4 | 2 | – | Bolt | St. |
| 3 | 2 | B18 | Half-Brass | Br |
| 2 | 1 | B17 | Cap | C.I. |
| 1 | 1 | B16 | Block | C.I. |

PILLOW BLOCK

Scale. Half-Size

March 29th 1918. J. Smith.

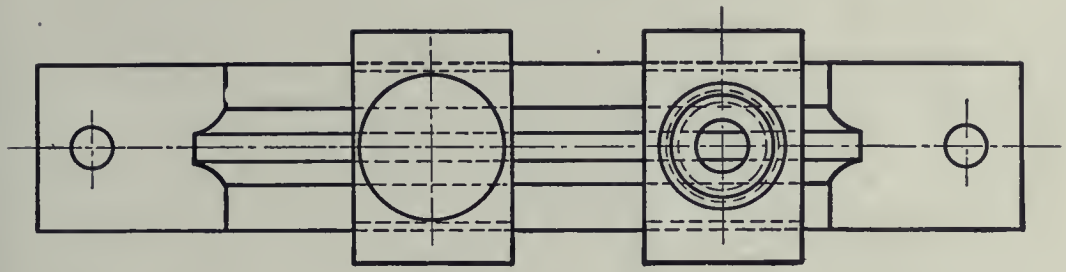
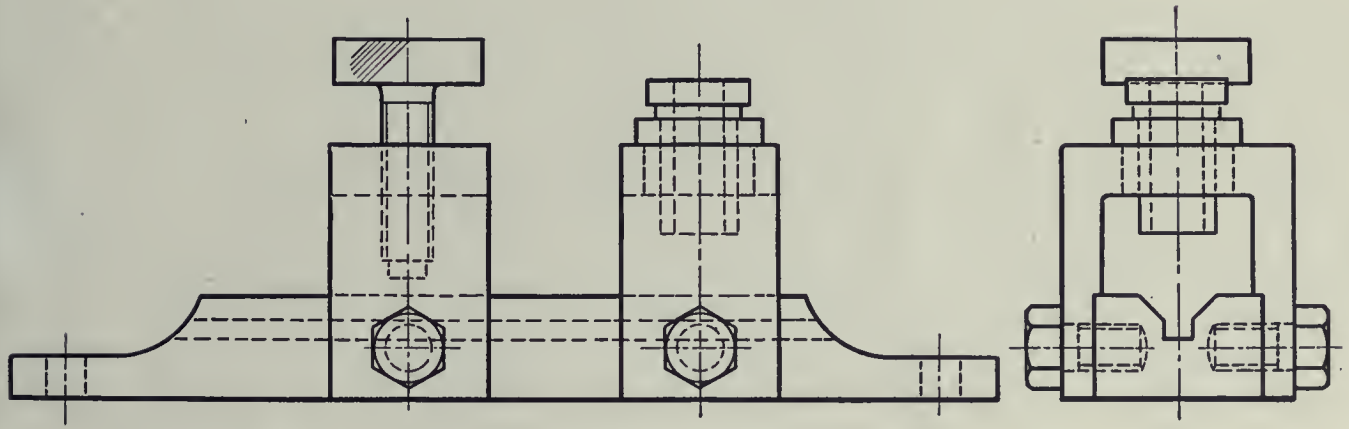
## Jig for Drill Press

The drawing on the opposite page shows a jig for holding iron rods when drilling holes through them.

Make an assembly drawing of such a jig and a detailed working drawing of each part, using a suitable scale and putting all the views on one plate of the necessary size. The student should decide first how many views of the assembled tool and of each part are necessary, the space each will occupy, and its position on the plate. (See page 74.)

As explained on page 72, assembly drawings are not dimensioned and detail drawings are dimensioned.

Detail drawings must bear all necessary explanatory notes and markings, especially those with reference to finish.

Make out a bill of material similar to that shown on page 75.

The jig as designed should be suitable to hold round bar stock 1 inch to 2 inches in diameter. It is left to the student to decide the dimensions of and materials to be used in the different parts.